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# Developing a Hyperspectral CLose UP Imager With UV Excitation (HyperCLUPI) for Mars Exploration

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## Abstract

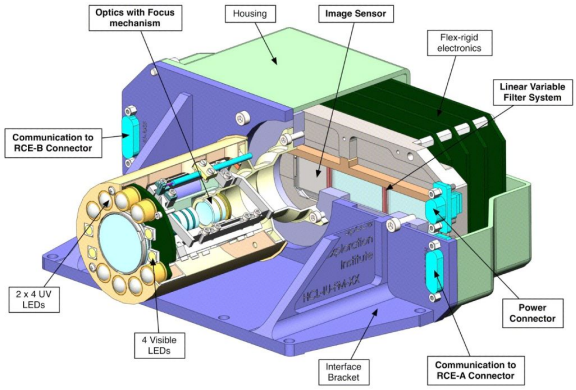
The HyperCLUPI concept incorporates a high resolution, hyperspectral and conventional colour, variable focus camera system which can image targets with resolutions from meters to microns per pixel. The hyperspectral element in combination with fine-scale imaging and UV excitation provides a unique capability that would enable the remote and non-destructive detection and characterisation of priority Mars science targets such as hydrated mineral deposits and organic compounds; key to the search for life on Mars. HyperCLUPI offers new opportunities for planetary science given its spatial and spectral capabilities, and this paper describes elements of the ongoing HyperCLUPI development work.

## 1. Introduction

The instrument is derived from the Swiss led ExoMars 2018 CLUPI (CLose UP Imager) instrument [1, 2], but enhanced by the addition of a UK developed hyperspectral element based upon a motor driven linear variable filter (LVF) mechanism, and UV and white-light LED science target excitation and illumination sources. As well as being able to operate in CLUPI-mode, these additions provide the ability to capture reflectance spectra over the visible to near infra-red multispectral AND hyperspectral range, and allow diagnostic detection of native fluorescence from minerals, and organics such as amino acids and polycyclic aromatic hydrocarbons (PAHs) following UV excitation.

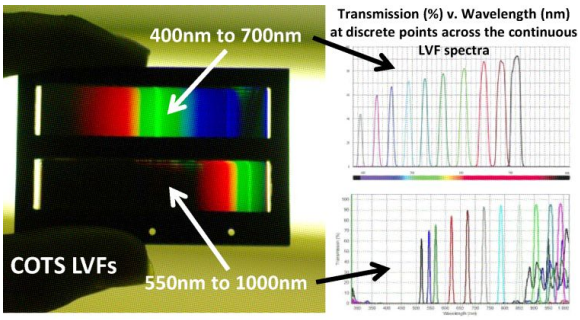
## 2. HyperCLUPI Science

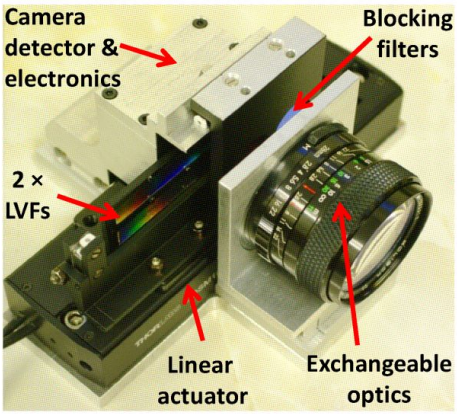
The hyperspectral component of HyperCLUPI enables an expanded scientific capability when compared to previous similar instruments. Science includes the




**HyperCLUPI open view** (Credit Space Exploration Institute)

VNIR (400nm - 1000nm) reflectance properties of rock and soil targets (predominantly geological science applications) and those made possible through the inclusion of UV LED excitation in combination with hyperspectral characterisation of the resulting native fluorescence response of mineral and organic deposits. This UV capability enables the detection of both discrete mineral deposits and any associated abiotic or biogenic organics. Specific science outputs of HyperCLUPI would at a minimum include: (a) High resolution colour imaging, 7$\mu$m per pixel @ 100mm; (b) VNIR hyperspectral identification of Fe-bearing silicates, carbonates, iron oxides, and sulphates; (c) NIR identification of the hydration state of minerals; (d) UV native fluorescence detection of high-priority hydrated minerals otherwise indistinguishable by their VNIR reflectance properties; and (e) UV native fluorescence detection of abiotic organics and organic biosignatures preserved within rock and mineral deposits. Native fluorescence responses of (d) and (e) targets can have highly-structured and fine-scale emission spectra and detection can only be achieved using the VNIR hyperspectral capability of HyperCLUPI.

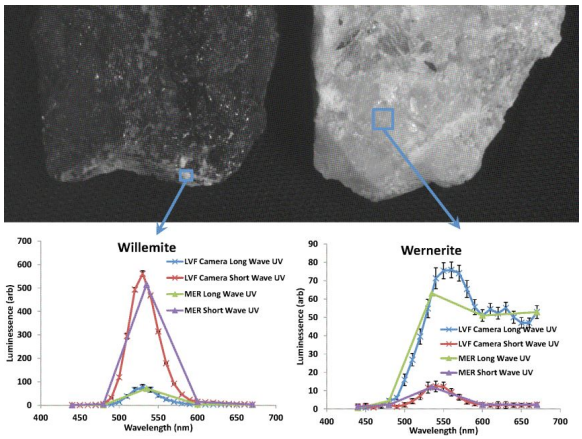



**Breadboard LVF Camera** (Credit Aberystwyth University)

## 3. HyperCLUPI Development

The CLUPI detector and associated electronics will be duplicated to provide the Imaging Unit for the HyperCLUPI instrument (total mass 1.7kg). As HyperCLUPI includes a hyperspectral LVF mechanism, UV and white-light LEDs, recent development work has focused upon these areas. The LVF is moved across the static detetector FoV, and currently the number and wavelength of the spectral channels can be selected up to a maximum of 75 at 8nm resolution. A breadboard LVF hyperspectral camera has been constructed using two COTS LVFs. Post calibration, preliminary tests have been conducted using Willemite and Wernerite samples illuminated using either long or short wave (365/254nm broadband) UV and the fluorescent light imaged using the LVF breadboard camera. The samples were chosen due to their high contrast and known response to UV excitation. Data were captured and processed to obtain 24 single wavelength images from 440 to 670nm and fluorescence spectra were obtained from regions of interest. The results were compared to simulated data using the NASA MER Pancam filter set and a significant improved quality from the breadboard camera has been observed.




**Breadboard LVF camera fluorescence measurements. Error bars show one standard deviation. Simulated data for the MER Pancam filter set (only 5 data points over this spectral range) show the improved quality of the data from a hyperspectral camera. (Credit Aberystwyth University)**

## 4. Summary and Conclusions

We are developing a Hyperspectral CLose UP Imager With UV Excitation (HyperCLUPI) for Mars Exploration that is derived from the Swiss led ExoMars 2018 CLUPI (CLose UP Imager) instrument. The addition of a hyperspectral LVF mechanism, and UV and white-light LEDs for science target excitation and illumination will allow HyperCLUPI to perform both fine-scale context and 'first-response' non-destructive, spatially-resolved analysis of mineral and organic targets within rocks and soils at the martian surface.

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## References

[1] J.-L. Josset, *et al.* CLUPI, a high-performance imaging system on the rover of the 2018 mission to discover biofabrics on Mars. In *EPSC-DPS Joint Meeting 2011*, page 790, October 2011.

[2] J.-L. Josset, *et al.* CLUPI, a high-performance imaging system on the ESA-NASA rover of the 2018 ExoMars mission to discover biofabrics on Mars. In *EGU General Assembly Conference Abstracts*, page 13616, April 2012.